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# Summary

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This thesis investigated the rovibrational structures of ethylene ( $^{12}\text{C}_2\text{H}_4$ ) and five of its isotopic variants: the  $^{13}\text{C}^{12}\text{CH}_4$  isotopologue, the *cis*- and *trans*- $\text{C}_2\text{H}_2\text{D}_2$  isotopomers, and the  $\text{C}_2\text{H}_3\text{D}$  and  $\text{C}_2\text{HD}_3$  isotopologues. Rovibrational analyses of 11 different ethylene bands and integrated band intensity and line intensity measurements of  $^{12}\text{C}_2\text{H}_4$  were carried out. Using a Bruker IFS 125 HR Fourier transform infrared spectrometer, the infrared absorption spectra of the different ethylene bands were measured and recorded with an unapodized resolution of  $0.0063\text{ cm}^{-1}$  at an ambient temperature of 296 K. Four *A*-type bands of the  $^{12}\text{C}_2\text{H}_4$  molecule were studied in  $1820 - 3105\text{ cm}^{-1}$  spectral region: the  $\nu_7 + \nu_8$  band in the  $1820 - 1950\text{ cm}^{-1}$  region; the  $\nu_6 + \nu_{10}$  band in the  $1985 - 2100\text{ cm}^{-1}$  region; and the  $\nu_{11}$  and the  $\nu_2 + \nu_{12}$  bands in the  $3000\text{ cm}^{-1}$  region. High-resolution spectroscopic work was also performed on the *A*-type  $\nu_{12}$  band of  $^{13}\text{C}^{12}\text{CH}_4$  in the  $1360 - 1520\text{ cm}^{-1}$  region, the *C*-type  $\nu_7$  band of *cis*- $\text{C}_2\text{H}_2\text{D}_2$  in the  $740 - 950\text{ cm}^{-1}$  region and the hybrid *A-B* type  $\nu_4 + \nu_8$  band of *trans*- $\text{C}_2\text{H}_2\text{D}_2$  in the  $1730 - 1940\text{ cm}^{-1}$  region. In addition, separate high-resolution studies of the hybrid *A-B* type  $\nu_6$ , the *A*-type  $\nu_3$  and the *A*-type  $\nu_{12}$  bands of  $\text{C}_2\text{H}_3\text{D}$  in the  $1100 - 1475\text{ cm}^{-1}$  region and the *C*-type  $\nu_8$  fundamental band of  $\text{C}_2\text{HD}_3$  in the  $840 - 980\text{ cm}^{-1}$  region were performed. The single-state rovibrational analyses of the bands were carried out using a standard Watson's Hamiltonian written in asymmetric reduction and  $I^f$  representation to determine each band's first excited state parameters including the band center, rotational

constants and higher-order centrifugal distortion terms. Ground state combination differences analyses performed using the infrared measurements of  $^{13}\text{C}^{12}\text{CH}_4$ , *cis*- $\text{C}_2\text{H}_2\text{D}_2$ , *trans*- $\text{C}_2\text{H}_2\text{D}_2$ ,  $\text{C}_2\text{H}_3\text{D}$  and  $\text{C}_2\text{HD}_3$  also yielded accurate ground state parameters for these molecules. Overall, the sets of ground state and first excited state rotational and centrifugal distortion parameters determined from the analyses were more accurate than those reported in the literature. The integrated band intensities of  $^{12}\text{C}_2\text{H}_4$  in the 640 - 3260  $\text{cm}^{-1}$  region were also measured using Fourier transform infrared spectra collected at 0.5  $\text{cm}^{-1}$  resolution and at more than 30 different vapor pressures ranging from  $3 \times 10^{-5}$  to  $1 \times 10^{-3}$  atm. The integrated band intensities of the  $\nu_9$  and  $\nu_2 + \nu_{12}$  (combined),  $\nu_{11}$ ,  $\nu_6 + \nu_{10}$ ,  $\nu_7 + \nu_8$ ,  $\nu_{12}$  and  $\nu_7$  and  $\nu_{10}$  (combined) bands measured from this study were more accurately determined than those found in the literature. Finally, line intensities of the  $\nu_7 + \nu_8$  band of  $^{12}\text{C}_2\text{H}_4$  were also measured using a Voigt profile fitted to each of the 123 peaks considered. The fit was satisfactory and the agreement between the measured and calculated line intensities was within  $\pm 6\%$ . The accurate molecular parameters and other spectroscopic information obtained by this study may be used as reference in modeling the concentration and abundance profile of ethylene in the Earth's atmosphere and beyond.